Pedobiologia **42**, 574–578 (1998)
Gustav Fischer Verlag Jena

*OECD WORKSHOP ON TERRESTRIAL FLATWORMS, NEW ZEALAND 1998*

# Potential problems posed by non-indigenous terrestrial flatworms in the United Kingdom

**D. V. Alford***

ADAS, Boxworth, Cambridgeshire CB3 8NN, UK

*Accepted:* 18. May 1998

**Summary.** Two non-indigenous predators of lumbricid earthworms are now well-established in the UK: the 'New Zealand flatworm' (*Artioposthia triangulata*) and the so-called 'Australian flatworm' (*Australoplana sanguinea alba*). Both species, but especially A. *triangulata*, are responsible for reducing earthworm numbers and the potential impact of this to the environment and to the agricultural/horticultural industry is discussed. The implication for international trade in hardy ornamental plants is highlighted, with particular reference to the need to minimize if not avoid future problems.

**Key words:** Planarians, New Zealand flatworm, Australian flatworm, *Artioposthia triangulata*, *Australoplana sanguinea alba*, earthworms, predation, plant health, UK

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## Introduction

The United Kingdom terrestrial flatworm fauna includes relatively few indigenous species (Ball & Reynoldson 1981), none of which poses any threat to man or has any obvious impact. Indeed, until relatively recently, even the establishment within the UK of the large, predatory 'New Zealand flatworm' (*Artioposthia triangulata* (Dendy, 1895)) was considered of little or no significance (e.g. Willis & Edwards 1977). Circumstances had changed dramatically by the early 1990s, with the realisation that this flatworm was capable of significantly reducing, or even eliminating, lumbricid earthworms from certain sites (Blackshaw 1989, 1990, 1991; Blackshaw & Stewart 1992; Boag et al. 1994a, b). Recently, concern has also been expressed in the UK about another introduced predator of earthworms, the so-called 'Australian flatworm' (*Australoplana sanguinea alba* (*sensu* Jones, 1981)) (Alford et al. 1996).

Within the UK, problems associated with non-indigenous flatworms are related mainly to the primary or secondary effects which ensue, or might ensue, as a result of a deleterious effect on earthworms. Restrictions imposed by regulations hinder possible field inoculation experiments and many United Kingdom observations on the impact of *A. triangulata* are based on the assumption that earthworm populations have been reduced by *A. triangulata* – experimental data are lacking. These potential deleterious effects are discussed in the present paper, with reference to two key areas: a) the environment and wildlife; b) agriculture and horticulture.

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* *Present address:* Orchard House, 14 Oakington Road, Dry Drayton, Cambridgeshire CB3 8DD, UK

## Environmental Problems

### *Direct impact on earthworms*

Following invasion by *A. triangulata*, earthworm numbers have been reduced to below detectable levels, at least in grassland sites in Northern Ireland (Blackshaw 1990). Although in certain situations, flatworms and earthworms are able to co-exist (for example, in some ornamental plant nurseries and garden centres in eastern Scotland), Lillico et al. (1996) reported that a lawn invaded by *A. triangulata* became depleted of both earthworms and flatworms.

In man-made sites favourable to colonisation by *A. triangulata*, earthworm numbers may be reduced significantly within a year (Christensen & Mather 1995). Although earthworm numbers typically recover following a decline in flatworms, Blackshaw (1995) reported that in sites in Northern Ireland the key species *Lumbricus terrestris* L. did not re-establish. This is surprising, as this species is known to be capable of extended surface migration and rapid colonisation of new sites (Mather & Christensen 1988, 1992). *A. sanguinea alba*, which often feeds gregariously, has less impact on earthworm populations than *A. triangulata* and tends to prey upon smaller hosts (Jones 1996); there is also evidence to suggest that members of the genus *Australoplana* are less determined predators than *Artioposthia* species (Yeates et al. 1997).

### *Secondary impact on fauna*

In the UK, earthworms are widely recognised as an important food source for mammals such as badgers (*Meles meles* (L.)), hedgehogs (*Erinaceus europaeus* L.), moles (*Talpa europaea* L.) and, to a lesser extent, shrews (*Sorex* spp.). In the badger, a species which is particularly reliant upon earthworms as food (e.g. Kruuk & Parish 1981), a significant reduction in the availability of earthworms would probably have adverse consequences on breeding success and survival. Further, moles, which are also highly dependent upon earthworms as food (e.g. Hawkins & Jewell 1962), could be lost from areas in which earthworms are eliminated. Hedgehogs, although feeding on earthworms, are mainly insectivorous (Matthews 1960) and would be far less affected by an absence or scarcity of earthworms.

Earthworms feature as a major component in the diet of certain birds, especially *Turdus* spp. (family Turdidae). Of these, the blackbird (*Turdus merula* L.) and, to a lesser extent, the song thrush (*Turdus ericetorum* Turton) are considered at greatest risk in the UK, particularly in areas where the flatworms (particularly *A. triangulata* but also *A. sanguinea* alba) have become established in private gardens.

Members of other vertebrate groups, e.g. slow-worm (*Anguis fragilis* L.) (Reptilia) and common toad (*Bufo bufo* (L.)) (Amphibia), include earthworms in their diet but in none are earthworms essential, as alternative food is readily available; nevertheless, earthworms are probably a major constituent of the diet of very young adders (*Vipera berus* (L.)) (Smith 1951).

Of the few invertebrates which include earthworms in their diet, shell-bearing slugs (*Testacella* spp.) feed only on earthworms. Such slugs, which are of rare occurrence in the UK, would be at serious risk of extinction if earthworm numbers were to decline even moderately.

Further details and examples are cited in the review by Alford et al. (1995).

### *Secondary impact on flora*

Following depletion of earthworms and consequent effects on soil structure, local waterlogging and periodic flooding could cause (and may have already caused) changes in flora, most

noticeably the development or expansion of stands of rushes (*Juncus* spp.) or sedges (*Carex* spp.) in permanent grassland.

In woodlands, accumulation of acidic leaf litter as a result of reduced earthworm activity could lead to faunistic changes, with calcicolous species being replaced by less-calcicolous ones. In the longer-term, the absence of earthworms could also have a detrimental effect on the growth of seedling trees, which might be out-competed by shrub-layer species so that the formation of climax woodland is delayed or even prevented (Alford et al. 1995).

### *Agricultural/horticultural problems*

In general, any effects on agricultural and horticultural production within the United Kingdom, following the establishment of flatworms such as *A. triangulata*, are thought to be minimal (see Alford et al. 1995). Nevertheless, poor field drainage and increased incidence of flooding, owing to a) the loss of earthworms, b) the subsequent blocking of old, vacated earthworm burrows and c) the absence of new earthworm workings are potential problems on permanent grassland in which *A. triangulata* becomes established. In such areas, wet conditions could increase the incidence of foot-rot amongst cattle and sheep; they might also increase the risk of infection of sheep by liver fluke (*Fasciola hepatica* (L.) (Platyhelminthes: Trematoda: Digenea)), by encouraging survival of the fluke's intermediate host – the dwarf pond snail (*Lymnaea truncatula* (Müller) (Mollusca: Gastropoda: Pulmonata)). Pasture productivity could also decline were there to be an increase in the presence of less-palatable, damp-tolerant grasses, rushes (*Juncus* spp.) and other weeds.

Within arable fields, and in intensive vegetable-growing areas, loss of earthworms following predation by flatworms could lead to a reduction in long-term fertility, as nutrients in organic material would not be mineralized efficiently; this would be of greatest significance for organic farming systems, under which inorganic fertilizers could not be used to rectify any deficiency. However, the extent of annual soil cultivation probably makes these sites less suitable for flatworm establishment than undisturbed permanent grassland. Cultivation can also lead to reductions in earthworm activity and numbers (Springett et al. 1992), so such sites are also intrinsically less favourable feeding grounds for flatworms. As indicated by Christensen & Mather (1995), significant outbreaks of flatworms are dependent upon there being a sufficiently high concentration of earthworm prey.

As in permanent grassland, the greatest potential effect on cropping is likely to be related to drainage problems with, possibly, increased likelihood of soil erosion during heavy rainfall. Poor drainage could also result in lower than average soil temperatures in spring, which could retard early-season growth and, in the case of spring-sown crops, might have a detrimental effect on crop establishment, especially in the wake of seedling-pest problems (e.g. flea beetles on brassicas and linseed crops; *Sitona* weevils on *Vicia* bean crops). Haria (1995) has further speculated on hydrological and soil structure problems, and suggested that under flood conditions there could be an increased risk of pesticides and fertilizers polluting surface water courses.

Currently, the most important problem associated with the presence in the United Kingdom of predatory flatworms is the potential effect on international trade in container-grown hardy ornamental plants. This is highlighted as certain countries in continental Europe, notably Sweden, are particularly concerned to avoid importing non-indigenous flatworms and are pressing for stricter controls. Local trade within the United Kingdom could also suffer were there to be a reluctance amongst the public to purchase plants from nurseries or garden centres known to be, or suspected of being, infested with flatworms. At present, however, there is no evidence to suggest that this is happening. Certainly, in parts of the United Kingdom where *A. triangulata* is established, plant producers are now taking additional hygiene measures to avoid flatworm contamination of pots and other containers; in an extreme case in Northern Ireland, as a direct result of persistent flatworm problems, one grower even resorted to rearing all containerized plants on raised benches (Alston 1991).

## Discussion

The primary effects on the hosts of large non-indigenous terrestrial flatworms should not be ignored but it is the knock-on effects resulting from the depletion of earthworm populations which are considered of particular significance and of greatest concern. Indeed, the perceived potential environmental impact of New Zealand flatworm resulted (in 1992) in this species being scheduled in Great Britain under The Wildlife and Countryside Act, 1981 which lists "species of animals which may not be released or allowed to escape into the wild". To date, the impact of the widespread infestations of *A. triangulata* in Scotland and Northern Ireland has apparently been relatively minor, although examples indicative of local habitat change (resulting from earthworm loss and subsequent drainage problems) have occurred in both countries. The next most abundant non-indigenous United Kingdom species (*A. sanguinea alba*) appears less potentially damaging than *A. triangulata* but future unwelcome flatworm visitors, should these arrive and become established, might prove more of a problem under United Kingdom conditions than the existing species.

Circumstantial evidence links the discovery, in Scotland in 1996, of another large species of non-UK origin to the presence of a recently planted *Camellia* bush (Jones & Gerard in press). There is considerable international trade in *Camellia*, with plants raised in New Zealand (mainly in the Taranaki region, where the native flatworm fauna is poorly known) exported direct to both the United Kingdom and continental Europe, suggesting a possibility of how this as yet undescribed species could have reached the United Kingdom. Certainly, there have been recent accidental introductions of Australasian plant pests into Northern Europe in association with ornamental plants, despite border controls. These include the New Zealand flax mealybug (*Trionymus diminutus* Leonardi) (Homoptera: Pseudococcidae), a pest now especially common on *Cordyline australis* and *Phormium tenax* in parts of Southern England (Alford 1997), and the pittosporum psyllid *Trioza vitreoradiata* (Maskell) (Homoptera: Triozidae), which has quickly become an important pest of *Pittosporum* spp. in the Isles of Scilly and elsewhere in South West England (Malumphy & Creek 1994). Fortunately, these phytophagous pests have a limited host range and they do not affect the native UK flora; nor, unlike terrestrial flatworms, are they expected to have any secondary environmental impact.

Predatory flatworms accidentally introduced from abroad, although not classified as plant pests, pose at least potential problems within the plant-producing industry, primarily in relation to international horticultural trade in containerized ornamental plants. United Kingdom Plant Health authorities are aware of the need to prevent the accidental inclusion of non-indigenous flatworms within consignments of locally or more widely exported plant material and have recently published a Code of Practice for nursery stock producers and traders, including garden centres, to prevent the spread of such organisms (Anon. 1996). It is hoped that the measures outlined within the Code will become an industry standard, will prove beneficial to the industry and will help to reduce the possible extent and impact of future (perhaps more devastating) flatworm problems in the UK and elsewhere. In the interest of continuing international trade, there is also a need for dialogue between plant health authorities in Europe and those countries with diverse terrestrial flatworm faunas, and adoption of more stringent quarantine controls than those currently in force.

## Acknowledgments

I thank Dr B. Boag (Scottish Crop Research Institute, UK) and Mr P. M. Johns (University of Canterbury, New Zealand) for commenting upon the draft manuscript and the Ministry of Agriculture, Fisheries & Food for financial support. Participation in the workshop was made possible by funding from the OECD Co-operative Research Programme: Biological Resource Management for Sustainable Agricultural Systems.

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